

METHODS AND APPARATUS FOR CUTTING ARTICLES CONTAINING AT LEAST A SUBSTANTIAL AMOUNT OF WOOD

FIELD OF THE INVENTION

The present invention pertains to the woodworking industry and, more particularly, to coated cutting tools for cutting articles containing at least a substantial
5 amount of wood.

BACKGROUND OF THE INVENTION

Steel cutting tools have been used for centuries in the woodworking industry. One reason for the use of steel cutting tools is the ability to form an optimal cutting edge
10 in steel, so that the cut wood has a relatively high quality finish immediately after the cutting. More recently and in an effort to prolong the useful life of cutting tools used in the woodworking industry, steel cutting tools with tungsten carbide tips and cutting tools formed from metal alloys have been used. Additionally, tungsten insert tooling and polycrystalline diamond fused to tungsten carbide substrates have been used.
15 Nonetheless, completely steel cutting tools are often still a very popular choice in the woodworking industry, due, for example, to cost and quality-of-cut considerations.

Additionally, coatings have been applied to cutting tools used in the woodworking industry in an effort to prolong the useful life of the tools. However, such coated tools have had limited commercial success in the woodworking industry, which is indicative of
20 prior coated tools for the woodworking industry failing to sufficiently satisfy the need for economical cutting tools that are capable of making quality cuts throughout relatively long production runs.

In contrast to the woodworking industry, coated cutting tools have been more widely used in the metalworking industry. Examples of coatings used in the
25 metalworking industry are disclosed in U.S. Patent Nos. 4,992,153 and 5,707,748, both of which are incorporated herein by reference. However, distinctions that exist between the woodworking industry and the metalworking industry are evidence that these industries

are nonanalogous fields of art. For example, metal can be many times harder than wood. Additionally, significant variations can exist in a single piece of wood. For example, these variations can be the result of variation in the density of the wood structure, variation in the moisture content of the wood, variation in the interlock and variability of the grain of the wood, hard mineral deposits within the wood, and variations in tension within the wood. Another vast difference in the woodworking and metalworking industries pertains to the use of liquid lubricants/coolants. More specifically, it is conventional to apply liquid lubricant/coolant to a piece of metal that is being cut, but it is typically unacceptable to apply such liquid lubricant/coolant to a piece of wood being cut, because the wood can absorb some of the liquid lubricant/coolant or otherwise be damaged thereby, which can render the wood unacceptable for many uses.

Needless to say, there is always a demand for improved cutting tools for the woodworking industry, with the ideal cutting tool optimally balancing factors such as cutting tool cost, cutting tool longevity, and cut quality. This demand has not previously been fully satisfied. For example and as mentioned above, coated cutting tools have found limited commercial success in the woodworking industry. Additionally, many attempts to find a coating for use on cutting tools in the woodworking industry have failed, due to the resulting coated tools providing little, if any, improvement over similar cutting tools without the coating. Accordingly, there is a need for improved coated cutting tools for use in the woodworking industry.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, problems are solved by providing a coated cutting tool and using the coated cutting tool to cut a plurality of first workpieces, with each first workpiece being wood or including a substantial amount of wood, to produce a plurality of second workpieces from the first workpieces. More specifically regarding this aspect, the coating is preferably applied via a vacuum procedure to at least a portion of the cutting tool that includes the cutting edge, and the coating preferably includes an inner hard layer and an outer friction-reducing layer over the hard layer. The hard layer is harder than the friction-reducing layer and the friction-reducing layer has a lower coefficient of friction than the hard layer. As a result, the

performance of the coated cutting tool advantageously exceeds the performance of a like but uncoated cutting tool.

In accordance with another aspect of the present invention, the coated cutting tool is cryogenically treated to advantageously further enhance its performance.

5 In accordance with one aspect of the present invention, the cutting tool is steel, and the coating consists essentially of the hard layer lying directly on the cutting tool and the friction-reducing layer lying directly on the hard layer.

In accordance with one aspect of the present invention, the hard layer includes titanium aluminum nitride, and the friction-reducing layer includes tungsten carbide with
10 carbon.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

15 Figure 1 is a flow diagram illustrating operations for providing a coated and cryogenically treated cutting tool and using the cutting tool to cut articles containing at least a substantial amount of wood, in accordance with a first embodiment of the present invention;

Figure 2 is a pictorial view of a cutting tool, namely a coated knife, in accordance with a first example of a second embodiment of the present invention;

Figure 3 is a left side elevational view of the coated knife of Figure 2; and

Figure 4 is a schematic, partial and enlarged cross-section view taken along line 4-4 of Figure 3.

25 DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these
30 embodiments are provided so that this disclosure will be thorough and complete, and will

fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

In accordance with one aspect of the present invention, a conventional cutting tool is coated with a predetermined coating and thereafter optionally cryogenically treated, so that the operational characteristics of the cutting tool are advantageously enhanced with respect to its use for cutting a workpiece that is wood or that includes a substantial amount of wood.

First Embodiment

Figure 1 is a flow diagram illustrating operations for providing a cutting tool and using the cutting tool to cut articles containing at least a substantial amount of wood, in accordance with a first embodiment of the present invention. Referring to Figure 1, a conventional cutting tool is provided and a cutting edge of that tool is formed and/or sharpened at block 10. In accordance with the first embodiment of the present invention, the cutting tool that is the subject of blocks 10-35 of Figure 1 can be any type of cutting tool used to cut a workpiece that is wood or includes a substantial amount of wood. For example, the cutting tool can acceptably be, but is not limited to, an insert having one or more cutting edges and that it is capable of being rotated in a cutter, a corrugated cutting knife, spiral cutter heads, tongue in groove insert cutters, fingerjoint cutters, rip saw blades, router bits, drill bits, and the like. As an additional example, the cutting tool can be steel, carbide, or any other material.

A multi-layer coating is applied to the cutting tool, or at least to the cutting edge formed at block 10, at blocks 15 and 20. More specifically, a relatively hard layer is applied over at least a portion of the cutting tool that includes the cutting edge at block 15, and then a friction-reducing layer is applied over the hard layer at block 20. The hard layer applied at block 15 is harder than the friction-reducing layer applied at block 20. The friction-reducing layer applied at block 20 has a lower coefficient of friction than the hard layer applied at block 15.

In accordance with the first embodiment of the present invention, the coating applied at blocks 15 and 20 is preferably applied using vapor deposition processes, most preferably with the hard layer being titanium aluminum nitride and the friction-reducing

layer being tungsten carbide with carbon. A suitable vapor deposition process is described in U.S. Patent Nos. 4,992,153 and 5,707,748, which have been incorporated herein by reference. In accordance with the first embodiment of the present invention, the thickness of the coating is about 2 to 6 micrometers, with the relatively hard inner
5 layer occupying about 2/3 of the thickness and the friction-reducing outer layer occupying about 1/3 of the thickness. After the coating is applied at blocks **15** and **20**, the coating has a hardness of about 90 on the Rockwell C Scale, in accordance with the first embodiment of the present invention.

As will be discussed in greater detail below, the coating applied at blocks **15** and
10 **20** advantageously enhances the performance of the cutting tool. When the cutting tool that is being coated is steel, special techniques are advantageously not required for maintaining the coated steel cutting tool. For example, the coated steel cutting tool can advantageously be sharpened with grinding tools that are typically used for steel cutting tools.

15 In accordance with alternative embodiments of the present invention, the coating applied at blocks **15** and **20** can include any of the combinations of relatively hard and friction-reducing layers disclosed in U.S. Patent No. 5,707,748, or the like.

In accordance with the first embodiment of the present invention, the entire coated cutting tool, or at least a portion of the coated cutting tool that includes a cutting
20 edge, is cryogenically treated at block **25**. The cryogenic treating that occurs at block **25** further enhances the performance of the cutting tool. More specifically, it is believed that the performance of the coating applied at blocks **15** and **20** as well as the performance of the underlying material of the cutting tool is enhanced by the cryogenic treating performed at block **25**.

25 In accordance with the first embodiment of the present invention and disregarding the item being cryogenically treated, conventional cryogenic techniques are used at step **25**. More specifically, at block **25** the temperature of the coated cutting tool is lowered to -300° F, with the lowering of the temperature being spread over a period of about six to ten hours, to avoid thermally shocking the coated cutting tool; then the temperature of the
30 cutting tool is held at approximately -300° F for about eight to forty hours; and then the temperature of the coated cutting tool is warmed to about 72° F, with the warming being

spread over a period of about eight to twenty hours. In accordance with the first embodiment of the present invention, the cryogenic treating that occurs at block 25 advantageously changes both the microstructure of the cutting tool and the microstructure of the coating on the cutting tool.

5 The coated and cryogenically treated cutting tool is mounted in a conventional manner to a conventional cutting machine at block 30. Thereafter at block 35, the combination formed at block 30 is used to cut first workpieces with the cutting edge of the coated and cryogenically treated cutting tool, to produce second workpieces. In accordance with the first embodiment of the present invention, the first workpieces are
10 boards, or the like, that are solid pieces of wood; or boards, or the like, containing a substantial amount of wood, such as medium density fiberboard (MDF) and particle board, both of which include multiple pieces of wood that are glued together. Preferably the cutting operations of block 35 are repeated in close succession for the same cutting machine and cutting tool, so that multiple second workpieces are quickly produced from
15 first workpieces by cutting the first workpieces serially and in rapid succession.

 During the cutting operations at block 35, the coating on the cutting tool reflects heat generated due to various factors of the woodworking process, so that heat is reflected away from the cutting tool and therefore does not damage the cutting tool. Reflecting the heat advantageously dramatically slows the process of dulling the cutting
20 edge of the cutting tool. Additionally, the friction-reducing layer of the coating on the cutting tool has a much lower coefficient of friction than steel. For example, the friction-reducing layer feels about four times slicker than steel alone. This allows the wood chips, or the like, being generated during the cutting at block 35 to flow away from the cutting tool faster and more efficiently with the coating than without. This not only
25 reduces the heat buildup on the cutting tool, but also advantageously reduces the number of chips that are forced back down onto the area of the workpiece that is being cut. The accumulation of chips at the area of the workpiece being cut inhibits the cutting.

Second Embodiment

A second embodiment of the present invention is identical to the first embodiment of the present invention, except that the cryogenic treating at block **25** of Figure 1 is omitted, so that a coated cutting tool is mounted to a cutting machine at block **30** and thereafter the combination formed at block **30** is used for cutting at block **35**.

In accordance with an initial example of the second embodiment of the present invention, coated steel knives cutting MDF at block **35** have yielded a tool life that was more than half the life of uncoated tungsten carbide knives, making steel knives that are coated with the coating of the present invention a cost effective alternative to more expensive tungsten carbide knives. In many applications, coating a steel cutting tool with the coating of the present invention increases the life of the tool by at least about 50% and allows for optimization of feed rates.

First Example Of Second Embodiment

In accordance with a first example of the second embodiment of the present invention, the coated cutting tool is a coated knife, namely a coated corrugated steel knife **40** that is illustrated in Figures 2-4. The coated corrugated steel knife **40** includes a cutting edge **42** and a series of features on the top of the knife that can be referred to as corrugations **44**. The corrugations **44** include an alternating series of ridges and grooves extending between opposite sides of the knife **40**. In the enlarged and partial cross-sectional view of Figure 4, the coating on the steel base material **46** of the knife **40** is schematically shown. More specifically, the relatively hard layer **48** of the coating is directly on the base material **46**, and the friction-reducing layer **50** is directly on the relatively hard layer.

A first operational example and a first comparative example are partially presented in the following Table I to provide a comparison that is illustrative of advantageous aspects of the present invention. The first operational example quantifies the performance of knives **40** of the first example of the second embodiment of the present invention, and the first comparative example quantifies the performance of conventional knives that are like the knives **40** of the first operational example, except that the knives of the first comparative example were uncoated.

Example	Condition Of Knives At End Of Run	Finish Quality Of Second Workpieces At End Of Run
First Operational Example	Slightly dull but still good for more production.	Second workpieces were very clean and required minimal sanding.
First Comparative Example	Completely dull.	Second workpieces were beginning to show signs of negative clearance angle, and they required massive sanding.

Table I

As indicated by Table I, the knives 40 used for the first operational example advantageously outperformed the conventional knives used for the first comparative example. For both the first operational example and the first comparative example that are the subject of Table I, the first workpieces, from which the second pieces were cut, were pieces of wood, namely cottonwood, oak, hickory, cherry and maple; the first workpieces were fed into a moulder machine at about 120 feet per minute; the moulder machine was equipped with hydrolock cutter heads, each carrying three of the respective knives. For the first operational example, jointing of the knives was advantageously required only two to no more than three times per run. In contrast, for the first comparative example, jointing of the knives was required from six to eight times during each run. Those of ordinary skill in the art know about jointing the knives mounted to a moulding machine, namely that for each rotating cutter head a jointing block is placed proximate thereto to uniformly form the cutting edges of the knives carried by the cutter head. Those of ordinary skill in the art know that it is preferred to minimize the number of required jointing operations.

Those of ordinary skill in the art know that a conventional moulder machine includes multiple spindles, each of which is for carrying a cutter head to which two or more knives are mounted. A conventional moulder machine is capable of contemporaneously machining all four sides of a workpiece that is passing through the moulder machine. Accordingly, moulder machines are capable of machining complex

shapes, such as, but not limited to, picture frames, window casings, or crown mouldings in a single pass. Modern moulder machines have a series of drive rollers that move the workpiece through the moulder machine.

5 Second Example Of Second Embodiment

A second example of the second embodiment is identical to the first example of the second embodiment, except that the coating, namely the relatively hard and friction-reducing layers 48 and 50 of Figure 4, are applied to inserts for cutting, namely solid carbide inserts.

10 A second operational example and a second comparative example are partially presented in the following Table II to provide a comparison that is illustrative of advantageous aspects of the present invention. The second operational example quantifies the performance of coated inserts (i.e., bits) of the second example of the second embodiment of the present invention, and the first comparative example
15 quantifies the performance of conventional inserts that are like the inserts of the second operational example, except that the inserts of the second comparative example are uncoated.

Example	Run Time	Condition Of Inserts At End Of Run
Second Operational Example	85-100 hours.	Worn on cutting edge.
Second Comparative Example	30-40 hours.	Worn out.

Table II

20 As indicated by Table II, the coated inserts used for the second operational example advantageously outperformed the uncoated inserts used for the second comparative example. For both the second operational example and the second comparative example that are the subject of Table II above, the first workpieces were the

same wood species; the second workpieces were cabinet parts; the inserts were run on a variety of machines from moulders to shapers and custom machines; and at the end of each run the finish where the second workpieces had been cut was poor. As indicated by Table II, the coated inserts for the second operational example were advantageously
5 capable of performing much longer than the uncoated inserts for the second comparative example.

Exemplary coated cutting tools of a third embodiment of the present invention are identical to the exemplary coated cutting tools of the second embodiment of the present invention, except that each of the operations of blocks **10-35** of Figure 1 are performed in
10 accordance with the third embodiment of the present invention. That is, the exemplary coated cutting tools of the third embodiment of the present invention are cryogenically treated at block **25**.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings
15 presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.